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IS 12603 (1988): General Requirements for Future Wide-body Aircraft Cargo-systems and Compartments (Intermodal) [TED 14: Aircraft and Space Vehicles]

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(Reaffirmed 2003)

Indian Standard

GENERAL REQUIREMENTS FOR FUTURE WIDE-BODY AIRCRAFT CARGO-SYSTEMS AND COMPARTMENTS (INTERMODAL)

1. Scope — Specifies minimum performance, design and test requirements for future civil wide-body dedicated freighter aircraft equipment identified as a main deck unitized cargo handling and restraint system. It further outlines the general design requirements for the cargo compartment and envelope.

2. Terminology — For the purpose of this standard, the terms and definitions as given in IS : 7073 (Part 1)-1973 'Glossary of terms relating to air cargo pallets and containers: Part 1 Air cargo pallets' and IS : 7073 (Part 2)-1983 'Glossary of terms relating to air cargo pallets and containers : Part 2 Air cargo containers', shall apply.

3. Requirements

3.1 *Interface* — Cargo system and compartment compatibility with unitized cargo, other cargo, ground equipment, facilities and pertinent cargo-related aircraft physical and environmental features, including capacities and limitations, shall be clearly and completely defined.

3.1.1 *Cargo* — The ULD specifications as given in various Indian Standards and the cargo types as described in **3.2.1**, shall be considered as the cargo for the future dedicated freighter aircraft.

3.1.2 *Air vehicle cargo system* — The air vehicle cargo system shall provide for the handling and restraint of specified ULDs and outsize cargo in the aircraft.

3.1.2.1 *Conveyance* — The system shall provide for the conveyance of the ULDs across the aircraft threshold and in and out of the aircraft cargo compartment.

3.1.2.2 *Support and restraint* — The system shall provide for the structural support and restraint of the ULDs during flight and ground manoeuvre in a manner which will assure that cargo will not present a hazard to the aircraft or its crew, and shall be in accordance with the requirements of the appropriate air-worthiness regulatory body.

3.1.2.3 *Guidance* — The guidance features of the air vehicle cargo systems shall assure that positive control will be maintained over moving ULDs and that ULD excursions will remain within the aircraft cargo envelope. Compatibility at the interface with ground loading equipment shall be provided to assure guidance continuity.

3.1.2.4 *Powered movement* — The system equipment shall provide for powered movement and control of ULDs.

3.1.2.5 *Stick loading* — The system shall provide for individual and/or multiple unit stick loading and unloading of ULDs.

3.1.2.6 *Outsize cargo* — The system shall provide for the handling and restraint of outsize cargo within the limits of the aircraft.

3.1.2.7 *Uncertified ULDs* — The system shall be capable of handling and restraining uncertified ULDs, including standard containers which do not have continuous flat bottom surfaces. This capability may be provided directly by the cargo system through the use of adapters installed in the cargo system or on/under the ULD.

3.1.2.8 *Containers* — The system shall not impose unusual or peculiar requirements upon the ULDs which would be detrimental to the function of the ULDs in other transport modes.

3.1.2.9 *Component application* — Some system components applicable to the loading/unloading function may be introduced into the aircraft for that function but remain with the ground equipment.

3.1.2.10 *Optional ULDs* — Provisions may be incorporated for the handling of optional ULDs. Aircraft cargo system equipment pertinent only to optional ULDs or to outsize cargo may be provided either as optional on board equipment or as quickly removable kit-installed equipment.

Air Cargo Handling Sectional Committee, MCPD 8 [Ref : Doc : MCPD 8 (772)]

Adopted 22 November 1988

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3.1.3 *Aircraft physical and environmental features* — The aircraft cargo system and compartment shall be thoroughly compatible and integrated with those aircraft physical, functional, and environmental features which impact the system and the compartment.

3.1.3.1 *Physical and functional features* — Some example of the aircraft physical and functional features are : door opening size, shape and location, cargo envelope and clearances, cargo movement paths, sill height, cargo floor attitude and excursion, aircraft stabilization characteristics, crew location with respect to cargo compartment, cargo floor and fuselage structural characteristics. These features are further covered later in this standard.

3.1.3.2 *Environmental features* — Some example of the aircraft environmental features are : temperature, pressure, atmosphere, venting, vibration/shock, noise and lighting. These features are further covered later in this standard.

3.1.4 *Ground equipment* — The following specifications, standards, and recommendations shall be considered. Additional requirements may be obtained from equipment manufacturer's manuals, catalogues, and drawings (*see* IS : 11437-1985 Ground equipment requirements for compatibility with aircraft unit load device).

3.1.4.1 *Compatibility* — The ground equipment shall be fully compatible with the aircraft cargo handling system.

3.1.4.2 *Cargo alignment* — The combination of the aircraft cargo system, aircraft interfacing ground equipment, and aircraft physical features shall minimize the criticality of cargo positioning and aligning during loading/unloading.

3.1.4.3 *Facility* — With respect to interface of the aircraft and/or unitized cargo to the facility, the facility and the ground equipment can be considered as synonymous when only the function of loading and unloading the aircraft is considered.

3.2 *Loadability* — The chosen spectrum of cargo shall be readily loadable if the aircraft is to perform efficiently. The cargo compartment shall be sized to receive and contain the cargo utilizing most effectively, the volume determined to meet the performance requirements. The cargo aperture and envelope shall be located and sized, respectively, to meet the needs of the cargo and the handling system. which in turn, shall perform to meet the requirements of aircraft turn-around and unloading. There shall be no constraints on methods to load or unload the cargo compartment of the aircraft.

3.2.1 *Types of cargo* — The cargo compartment shall accept various types of unitized and non-unitized cargo.

3.2.1.1 *General cargo* — General cargo unitized in containers or on suitable pallets will constitute the majority of the civil freighter domestic and international cargo in future air cargo operations. The ULDs will encompass the ULD spectrum which shall be handled through the cargo aperture and in the cargo compartment.

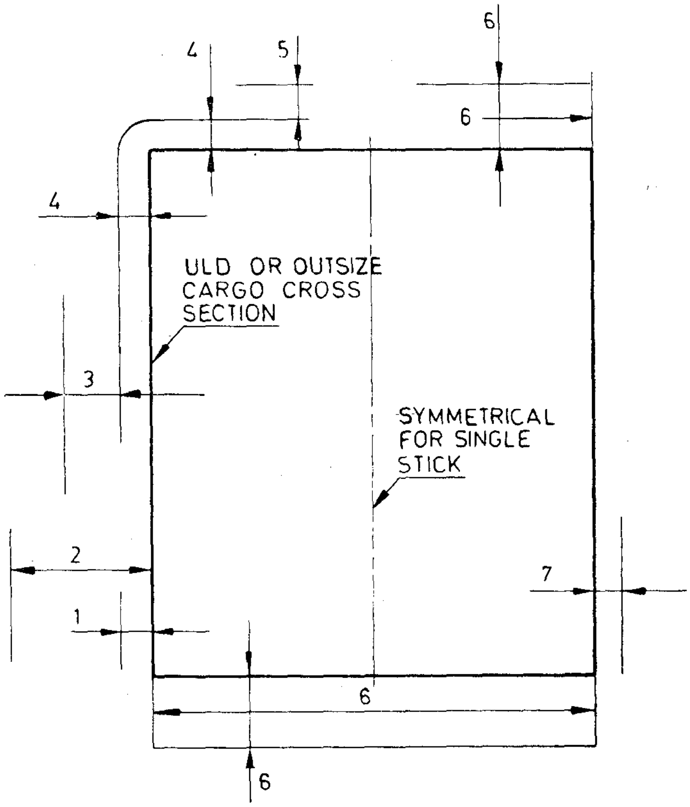
3.2.1.2 *Special cargo* — Special cargo is generally defined as cargo which may not be environmentally or physically compatible with the containers used for general cargo (*see* **3.2.1.1**) but will be handled on suitable pallets within the dimensions and weights defined for general cargo. This cargo may include liquids, autos, live animals, etc. Preservation of compatibility with ground transportation shall be considered a requirement.

3.2.1.3 *Outsize cargo* — Outsize cargo are those items incapable of being contained or restrained by the various ULDs, but that will fit with adequate clearance, the cargo envelope of the aircraft being developed. Bulk loading, special pallets or containers, dollies, or other means of entry and tiedown may be used depending upon the capability of the airframe and/or the design features desired by the buyer/user.

3.2.2 *Cargo envelope* — The size and shape of the cargo compartment and access therero shall have no constraints for receiving and restraining the specified spectrum of cargo. Criteria for applicable existing and proposed ULDs for the future cargo aircraft shall constitute the items used to determine the cargo envelope and, in turn, the fuselage contour. An efficient use of volume shall be achievable under maximum payload operations.

3.2.2.1 *Loading method effects* — Cargo compartment envelope sizing may be affected by loading methods. Proper positioning of the cargo within the compartment may also require design consideration for both the compartment and the loading equipment.

3.2.2.2 *Sizing factors* — Figure 1 shows various cargo envelope development sizing factors. A space allowance shall be provided for guidance and restraint equipment. This space may or may not fall within the clearance space provided between the payload and the structure. If required for outsize or other cargo, an additional space may be required for access to floor tiedowns. A space allowance shall be provided for personnel ingress along the inboard or outboard sizes of the cargo sticks. In addition to the basic clearance dimension of 51 mm between payload and structure during both the loading/unloading and restraint modes, there may be an additional localized clearance dimension requirement in threshold areas for the gyration (that is teetering, valleying, articulating) of the load in transit at the interface. A space allowance shall be made for the loading (conveyance) system equipment whether it be below or above the payload. Load separation in multi-stick arrangements shall be not less than 102 mm in a mechanical or automated system but could be much greater in a manual (floor tiedown) system. The largest factor in envelope development is the payload cross section. The composite payload cross section which forms the basis onto which the above clearances and space allowance are additive, shall be carefully considered. Where growth is probable in ULD gauge or height during the life of the aircraft, the growth dimensions shall also be considered.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4
5
6
4
ULD OR OUTSIZE CARGO CROSS SECTION
3
SYMMETRICAL FOR SINGLE STICK
2
7
1
6
6

1 Side restraint mechanism space allowance
2 Space for access to floor tiedown (if required)
3 Ingress for inspection by personnel
4 Clearance between load and structure
5 Clearance for load excursion in threshold area
6 Loading system equipment space allowance
7 Load separation in multi-stick arrangement

FIG. 1 CARGO ENVELOPE DEVELOPMENT FACTORS

3.2.2.3 *Crew location* — The flight station shall be located in a manner to facilitate both the movement of cargo in/out of the aircraft and to maximize usable volume of the cargo compartment. Additionally, advantage shall be taken of applicable reduced restraint criteria accorded aircraft whose cargo is not projected to pass through the flight station during an emergency/crash landing condition.

3.2.3 *Cargo compartment* — The cargo compartment accommodates the cargo during loading/unloading modes and contains and restrains it during ground manoeuvre and flight. The number of cargo sticks and the stick length determinations go beyond the scope of this standard. However, the sizing of the compartment with respect to a selected aircraft gross payload in kilograms is basically determined by the value set for the onboard unitized cargo design density. Sufficient trade-offs shall be evaluated utilizing cargo envelopes, payloads, ULD volumes and tare weights to achieve the needed cargo compartment dimensional sizing.

3.2.4 *Cargo aperture* — Cargo doors have the basic function of closing the loading access opening of the cargo compartment. No constraints shall be placed on the operation of the cargo doors. The aperture shall consider external cargo handling operations, such as, winching or hoisting of outsized cargo. Hinging, latching, actuation and sealing of the door shall not interfere with the basic function of loadability of the cargo compartment.

3.2.4.1 *Door location* — Cargo door location may be considered to be at the discretion of the aircraft designers. However, the location shall be selected and the path of cargo movement (that is straight-in, Y, 90° turn) shall be directed by the ability of the system to meet such performance parameters as turn-around times and the handling of all ULD sizes. Consideration shall be given to a location which will enable suitable ground loading equipment to manoeuvre easily into position. The door opening shall be such that it provides maximum clearance with the cargo envelope, and the full open position shall be the maximum allowed by the aircraft structure.

3.2.4.2 *Ground equipment clearances* — Cargo door (including visors) opening criteria shall be compatible with the requirements for clearance of ground interface loading equipment at the aircraft loading interface.

3.2.4.3 *Operating times* — Cargo door opening and closing times shall be as short as possible commensurate with safety and the unlocking, actuation, and locking operations. These times, however, shall not exceed 90 s.

3.2.5 *Cargo floor height* — This standard does not purport to specify a discrete cargo floor height. However, a range of cargo floor hights is desirable to provide the ground system equipment designers some finite parameters. The most important decision in this process is the determination of whether the cargo floor is above or below the aircraft wing (unless the aircraft is to be a distributed-load aircraft). This decision, when made, dictates whether the aircraft is high wing or low wing. In making this determination, it is important to evaluate the time effect of lift height on cyclic lift devices. There is no way to kit or add-on a capability to effect a substantial floor height change. Integral and/or removable kit loading ramps may be provided as requirements dictate for special ground loading operations. The cargo floor height of the aircraft to be developed shall fall between a minimum of 1 370 mm and a maximum of 5 490 mm.

3.2.6 *Aircraft stabilization* — The cargo floor of the future all-freighter aircraft can be expected, under changing cargo and fuel loads during loading/unloading operations, to incur (unless restrained) substantial changes in height and deck angle. This floor height/angle excursion is detrimental to the loading process, specially at the threshold floor sill location. Also, during the loading and discharge of cargo, tip-over of the aircraft shall be prevented. The aircraft shall be capable of being stabilized to provide a relatively constant floor height and deck angle during cargo handling. The degree to which change in height and attitude shall be controlled is a function of specifics of the cargo handling system and the tolerances to which it can accept cargo in transit at and across the threshold interface.

3.2.7 *Cargo handling* — The cargo handling system provides the interface between the cargo and the airframe. It also provides an interface with the ground interface loading equipment. Although certain types of cargo may be loaded manually, the basic cargo handling system shall be mechanical with powered drive for movement of cargo. The system shall have growth potential for operation by automated means. Aircraft systems design shall allow for simultaneous cargo handling and refuelling or line maintenance operations. Specific system recommendations are covered elsewhere in this standard.

3.2.8 *Ground system facility* — The ground system shall interface both the aircraft onboard cargo handling system and the ground transportation system. The ground system shall have the capability to load-unload the aircraft within the minimum load-unload times of the aircraft cargo handling system. This interface provides the intermodal aspect for the air-truck link of the air-sea-road-rail overall intermodal transportation system. The facility shall provide the necessary ramp, equipment, and building spaces to accommodate the ULD staging/storage requirements and the cargo loading/unloading and aircraft servicing operations.

3.2.9 *Loading access/inspection/verification* — Loading access/inspection/verification to the exterior of all ULDs shall be provided to assure the security and integrity of the cargo when restrained in the cargo compartment. This may include a combination of direct and/or remote means, such as, direct access, compartment lighting, fibre and/or reflective optics, micro-switches, or other applicable means to make such determinations. Consideration shall be given for access to cargo handling equipment in case of malfunction with cargo in place. Considerations may be extended to in-flight cargo monitoring functions.

3.3 *System Performance* — The system shall be designed with total consideration for all functions to be performed. The cargo system and compartment shall provide a capability for a maximum payload of unitized cargo with minimum loss of loadable volume.

3.3.1 *Performance standards* — The aircraft on board cargo system shall be designed to provide the capability for minimal turn-around times with high reliability, minimal cargo handling costs and the damage-free handling of cargo.

3.3.1.1 *Load-unload cycles* — With appropriate aircraft/ground interface equipment available, the cargo handling system shall be capable of discharging a full unitized cargo load in 15 min, and completely reloading the aircraft in 15 min. Five additional minutes shall be allowed for a changeover from unloading to loading. Aircraft positioning and door opening/closing times are not to be charged to the load/unload cycle times.

3.3.1.2 *Manloading* — Onboard manloading requirements shall not exceed 1 man per stick of cargo during normal ULD loading/unloading operations. This requirement is not necessarily applicable to optional ULDs or outsize cargo.

3.3.1.3 *Force* — If an onboard power system is provided, the frictional rolling or other force requirements shall not exceed 3 percent of the gross load weight when moving the load on a level surface, and the system shall further be capable of moving the load on the inclined surfaces of **3.3.1.4**.

3.3.1.4 *Loading system alignments* — The system at the interface between the aircraft and the ground loader/dock equipment shall function properly if the aircraft moves through a range from 2° nose down to 2° nose up and plus or minus 2° in roll attitudes during loading/unloading operations unless the aircraft is positioned and restrained. Relative crest or valley angle during load/offload shall not exceed 2°. A step of 9 mm up and 13 mm down shall be transversable by ULDs in transit.

3.3.2 *Functional characteristics* — The system shall consist of a low-friction load-bearing surface or device for conveyance of ULDs to and from their loaded position within the aircraft, powered ULD movement equipment, directional control equipment, and restraint devices.

3.3.2.1 *All-seasons operation* — All loading/unloading, power and restraint operations shall be capable of being accomplished by personnel encumbered with special clothing, such as, winter gloves.

3.3.2.2 *Special tools* — System equipment shall be designed to accommodate ULDs of one standard width and varying lengths, provided to accommodate ULDs of varying width. When this capability is provided, the adjustment shall be accomplished without special tools and shall be operable by personnel wearing winter clothing.

3.3.2.3 *System capabilities* — The system shall be capable of accommodating the maximum load for which each ULD is designed. The system should also accommodate heavier than specification ULD loads to the extent that the airframe can accept heavier local loadings. Aircraft structural capabilities may limit the final positioning locations of maximum weight loads within the aircraft.

3.3.2.4 *System growth* — This system shall consider growth to full automation with respect to the movement and restraint of ULDs.

3.3.3 *Structural compatibility* — The cargo compartment envelope basically defines the inside of its surrounding structural airframe shell. Because of inherently different flexure characteristics existent between airframe and ULDs, it is necessary to consider the level of structural compatibility and possible limiting conditions.

3.3.3.1 *Loads* — The airframe shell and cargo support structure shall be capable, through the cargo restraint system, of adequately restraining the cargo for both ground manoeuvre and flight loads. This shall be accomplished without damage to the aircraft or the cargo. Also, loads introduced during cargo loading/unloading shall be accommodated without damage. Consideration shall be given to zone loading restrictions normally associated with airframe structures. Load capabilities shall be provided in the distributed (force/area) and running (force/unit of length) manner. Additional capabilities (such as, concentrated, puncture, axle) may also be specified.

3.3.3.2 *Deflections* — The cargo support structure working with the cargo restraint system shall accommodate the range of deflections imposed by ground manoeuvres and flight loads. This shall be accomplished without damage to the aircraft or the cargo. Since aircraft structures in the interest of weight saving are relatively flexible and many container types of ULDs are relatively rigid, the introduction of highly concentrated loads of a crippling nature must always be of prime consideration. Thus, cargo support structures shall be designed for such concentrated loads or alternative methods employed for distributing the loads.

3.3.3.3 *Restraint* — Cargo restraint shall be provided through the interface system such that the ground manoeuvre and flight loads will not damage the aircraft or the cargo. The restraint interface is a function of the cargo interface and is further described in **3.1.2**, **3.2.4** and **3.7.3**.

3.3.3.4 *Weight and balance* — Cargo placement (location) in the cargo compartment is dictated by a combination of factors including foremost, the proper distribution of ULDs or other cargo of widely divergent gross weights to effect a proper aircraft centre-of-gravity. Secondly, zone loading capabilities shall not be exceeded and thirdly, placement for offloading at enroute stops shall be considered.

3.3.4 *Crash conditions* — The structural provisions and other features peculiar to the containment or control of cargo and the protection of crew and personnel during emergency landing operations shall be designed to meet the requirements of the appropriate air worthiness regulatory body.

3.3.4.1 *Barriers* — Cargo compartment bulkheads or barrier nets designed, when required, for crew and personnel protection during emergency landing operations shall incorporate means for access between compartments. Such access provisions during normal operations shall be operable by one man and the time for opening or closing shall not exceed one minute. If bulkheads, barrier nets, or other restraint barriers are employed in conjunction with the restraint of uncertified ULDs, similar ingress/egress features shall be provided. This requirements may not apply to fixed structural bulkheads.

3.3.4.2 *Structural fuses* — If structural fuses are employed, the fuse support structure shall be designed for 1·5 times more than the fuse.

3.3.4.3 *Crew safety* — Careful consideration for all aspects of regularory requirements for crew safety shall be made.

3.3.4.4 *Hazardous cargo* — Provisions shall be made for the carriage of hazardous cargo in compliance with appropriate hazardous cargo regulatory requirements. Positive provisions shall be made for in-flight inspection and/or monitoring.

3.3.5 *Environmental compatibility* — The cargo compartment shall provide an environment compatible with the requirements of the cargo for the time the cargo is aboard the aircraft. Additionally, the cargo compartment shall provide an environment compatible with the needs of the personnel whether they are loading and/or maintenance or flight personnel. Most functional equipment provided environmental requirements apply only to the cargo compartment when the aircraft is closed up and prepared for flight or in flight.

3.3.5.1 *Temperature* — The aircraft environmental system shall provide a cargo compartment temperature above freezing (0°C) when measured in any part of the loadable volume.

3.3.5.2 *Pressure* — The aircraft and its environmental system shall be capable of providing a pressure altitude for the cargo compartment of 5 486 m when the aircraft is at maximum cruise altitude. Customer requirements may, however, specify a lower cargo compartment pressure altitude suitable to the carriage of a greater spectrum of cargo/commodity types, and the flight station may be separated from the cargo compartment for pressurization.

3.3.5.3 *Venting and circulation* — Ventilation and circulation requirements shall be determined by the spectrum of cargo to be carried; for instance, inert cargo requires no ventilation whereas live animal cargo (if a customer requirement) required a ventilation rate of up to one air change every three minutes. The circulation capability shall assure that there are no static air pockets in the cargo compartment.

3.3.5.4 *Vibration/shock* — The cargo compartment and equipment shall be designed to withstand vibration levels of 4 mm from 5 to 1 000 Hz with a maximum acceleration of 20 m/sec^2 (2 *g*).

3.3.5.5 *Noise* — The cargo compartment shall have sufficient soundproofing to provide adequate noise protection for the types of cargo to be transported for a given length of flight time.

3.4 *Reliability/Maintainability* — System reliability and maintainability shall provide for high equipment availability.

3.4.1 *Replacement times* — When a failure occurs, the replacement time for repetitive high usage items including components (*see* **3.1.2.9**) shall not be more than 10 min. Major low usage items shall be capable of replacement in 30 min.

3.4.2 *Service life* — The major onboard components of the system, based on expected operational usage, shall have a service life equivalent to the aircraft airframe service life. Service components including components (*see* **3.1.2.9**) having a high frequency of use and exposure to fatiguing impacts, such as, latching devices, restraint fittings, guide rails, etc, shall have a design life expectancy of five years.

3.4.3 *Maintenance tools* — Assembly, disassembly, and maintenance (including servicing) shall be accomplished with general purpose tools and equipment normally and commercially available.

3.5 *Convertibility* — Equipment provided to handle and restain optional ULDs and/or outsize cargo shall be capable of quick erection/installation. Where applicable, this equipment may be kit installed. Auxiliary equipment in place shall not limit handling and restraint of basic ULD sizes. If a non-standard gauge option is exercised, the system shall be able to accommodate a stick composed of a mixture of basic and optional ULD size.

3.6 *Safety* — Safety of personnel, the aircraft, and the cargo shall be given prime consideration in the layout, design, and operation of all cargo handling and cargo compartment features and equipment.

3.6.1 *Personnel* — Provisions for the safety of personnel shall be incorporated with regard to anticipated operating conditions and the capabilities of the operating personnel. Special care shall be exercised to make safe the performance of necessary tasks by personnel working at or across the threshold area(s) and at the interface with ground loading equipment. Applicable current personnel safety regulatory standards shall be met.

3.6.2 *Cargo monitoring* — capability to monitor the security of cargo at all times when onboard the aircraft shall be a basic provision. The access, inspection, and verification of the integrity of the cargo with respect to its restraint and containment are covered in **3.2.9**. The monitoring of the security of the cargo shall also encompass, by direct or remote means, a surveillance of its well being with respect to environmental and other conditions.

3.7 *Design Requirements* — The following design guidance provides further product definition in those areas where sufficient knowledge exists to offer the same.

3.7.1 *General design consideration* — The following design parameters shall apply to all onboard cargo handling equipment components.

3.7.1.1 *System components* — The system components shall be minimum weight, simple, rugged, and low cost.

3.7.1.2 *Environment* — The system shall be capable of operating under the following conditions:

a) Temperature range from −32°C* to + 60°C,

b) Relative humidity up to 95 percent,

c) Exposure to salt-sea atmosphere,

d) Vibration incident to service use,

e) Sand and dust particles as encountered in desert areas,

f) Exposure to rain in cargo door area, and

g) Ice and snow in cargo door area.

3.7.1.3 *Impact loads* — System components shall be capable of withstanding impact loads resulting from rough handling. ULDs moving at speed up to 18 m per minute shall be considered unless speed limiting devices are used.

3.7.1.4 *Loose parts* — There shall be no loose parts which might be easily lost.

3.7.1.5 *Component weight and size* — The weight and size of any component installed on the aircraft shall permit installation and removal by not more than two men.

3.7.1.6 *Foolproofing* — Where improper installation of a part could cause malfunction of the part or the equipment in which it is installed, an unsymmetrical mounting means shall be provided. That mounting shall permit the item to be installed only on its proper operating position.

3.7.2 *Conveyance system* — The conveyance system shall consist of a device or devices suitable to the task of moving the ULDs in and out of the aircraft cargo compartment.

3.7.2.1 *Options* — The conveyance system may be either a part of the aircraft of the ground interface equipment or of both.

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*Where application includes an arctic environment, this figure should be changed to −54°C.

3.7.2.2 *Load bearing* — The conveyance device(s) may, but do not necessarily, form a load bearing surface capable of supporting the ULDs under the ground manouvre and light load conditions.

3.7.2.3 *ULD separation* — The minimum separation between ULDs in adjacent sticks shall be 102 mm. In determining the minimum required separation, the aircraft floor deflection, ULD restraint deflection, and ULD deflection shall be considered.

3.7.2.4 *Forces* — The horizontal force required for the movement of ULDs on a level plane shall be a minimum consistent with the conveyance device(s) employed, and also with the force limit set forth in **3.3.1.3** and **3.3.1.4** for both level and inclined surfaces.

3.7.2.5 *Exposed edges* — All exposed edges of conveyance devices/parts which contact the ULD or the aircraft shall be rounded to protect contact surface.

3.7.3 *Guidance* — Guidance system components shall maintain positive low friction lateral directional control and shall permit free longitudinal movement during loading operations.

3.7.3.1 *Rail location* — Rails, tracks, or fittings designed for lateral and/or longitudinal guidance shall be so spaced and located as to assure repeated final positioning of the ULD for restraint under the ground manoeuvre and flight conditions while also meeting the clearance specified in **3.7.2.3**. If also used for restraint, the total lateral clearance between the ULD edge and the rail, track or fitting surface shall be commensurate with the demands for lateral and/or longitudinal freedom during loading/unloading operations and for structural adequacy during the ground manoeuvre/flight regime. Specific ULD specifications shall be consulted in establishing these clearances.

3.7.4 *Restraint* — Devices/fittings designed for vertical restraint shall provide a maximum vertical clearance between the ULD surface and the restraint device surface commensurate with the overall restraint system concept needs. The interaction between the ULD and the restraint devices under the full spectrum of ground manoeuvre and flight load conditions shall be examined to assure that no undue local loadings are created by the differential stiffness of the ULD and the aircraft. The requirements of the applicable ULD specifications shall be consulted in establishing this detail design.

3.7.4.1 *Longitudinal freedom* — Devices/fittings designed to provide fore and aft restraint shall limit the longitudinal freedom to the maximum degree commensurate with the tolerances dictated by the ULD locating and positioning requirements and tolerances of the detail restraint engagement concept.

3.7.4.2 *Multiple functions* — Restraint devices/fittings shall be designed to accomplish multiple restraint functions where possible.

3.7.4.3 *Manloading* — The restraint devices shall be capable of being operated by one man without accessory tools orequipment.

3.7.4.4 *Performance* — All restraint devices for and single ULD position shall be capable of being operated by one man in less than half a minute without accessory tools or equipment.

3.7.4.5 *Positive indication* — The latching mechanism shall incorporate means whether manual or automatic, to determine and provide positive indication of ULD restraint.

3.7.4.6 *Load complement* — The restraint system shall satisfactorily accommodate less than a full complement of ULDs for flight.

3.7.4.7 *Uncertified ULDs* — The ULD restraint concept shall include the capability to satisfy regulatory restraint criteria for uncertified ULDs unencumbered by ancillary devices or special restraint equipment.

3.7.5 *Power equipment* — Power drive equipment shall provide the longitudinal and lateral (where necessary) force for the movement of ULDs in the aircraft during loading/unloading operations in accordance with **3.3.1.3** when the aircraft attitude is within limits. Consideration shall be given to provide positive traction under adverse environmental conditions.

3.7.5.1 *Control* — The equipment shall provide for braking and positive fore-aft or lateral control of the loads under all aircraft attitudes described in **3.3.1.4**. The power drive equipment and the guidance equipment shall provide positive positioning of the ULDs for restrait.

3.7.5.2 *Override* — The power drive equipment shall be capable of being manually overridden or retracted within five minutes in case of malfunction to permit movement of the cargo. The power drive system shall provide for loading and off-loading ULDs with an inadvertent 'power off' condition.

3.7.5.3 *Equipment* — Power equipment may either be part of the aircraft cargo system or of the ground interface equipment or of both.

3.7.5.4 *Lift/set-down* — The power equipment may also lift and set down ULDs during loading/unloading movement if this is necessitated by the cargo system concept.

3.7.5.5 *Control location* — Power equipment controls shall be located at the most advantageous location for the operator to safely control the loading process. This location may be in the threshold area inside and/or outside of the aircraft. Additional controls, if necesary, may be spaced incrementally down the length of the cargo compartment.

3.7.5.6 *Inoperable* — The powered cargo transfer system shall be inoperable during flight.

3.7.6 *Structural considerations* — The aircraft cargo floor and underfloor structure shall be adequate to react through the cargo system, the ULD handling loads and the ULD loads incident to ground manoeuvre and flight operations.

3.7.6.1 *Floor continuity* — The extent and continuity of the cargo floor shall be consistent with the needs of the specific cargo system employed.

3.7.6.2 *Personnel suitability* — The cargo floor shall be suitable for the needs of both cargo and aircraft maintenance personnel. Provision for the drainage of liquids shall be included. Walkways shall incorporate an anti-skid surface.

3.7.6.3 *Floor discontinuity* — If the cargo floor is discontinuous, consideration shall be given to the safety of cargo handling and maintenance personnel to prevent damage to under floor structure and fuselage shell; to prevent the collection of dirt, debris and liquids in the bilge area; to drainage and anti-skid requirements; and to the environmental control of the cargo compartment.

3.7.6.4 *Normal capability* — Air frame structural characteristics shall be compatible with the requirements of the ULDs and the aircraft cargo system. Airframe structural characteristics shall be such that rigid ULDs up to 12·2 m (40 ft) in length and 20 412 kg gross weight may be routinely accommodated with no requirement for ULD flexible joints or flexible structure, and with no adverse effect on system serviceability.

3.7.6.5 *Special capability* — Airframe structural provisions shall also be such that ULDs of 20 320 kg gross weight for the 6·1 m (20 ft) length and 30 480 kg gross weight for 12·2 m (40 ft) length may be handled and transported in selected cargo compartment locations.

3.7.6.6 *Special restraint* — Structural provisions shall be made for the special restraint requirements of outsize and overweight cargo within the basic airframe capability of the aircraft. Removable kit installations may be employed to meet this specialized requirement.

3.7.6.7 *Containment* — Structural containment configurations which can accept uncertified ULDs shall be a basic airframe feature.

3.7.7 *Threshold equipment* — Cargo door sill equipment, designed to ease the transfer of ULDs into the aircraft, may be either a part of the system or it may be a part of the ground equipment or terminal facilities.

3.7.7.1 *Door sill* — The cargo door sill or sill equipment shall incorporate provisions for the attachment of ground loading equipment bridge or other similar ground interface equipment. The door sill shall be capable of supporting the maximum ULD local loading permissible in the aircraft.

3.7.7.2 *Compatibility* — Ground equipment utilized to perform the transfer function across the interface shall be designed to be compatible with the associated aircraft physical and functional features affecting the transfer, that is, floor height, floor excursion, roll and pitch angles, stabilization characteristics, cargo aperture and cargo envelope.

3.7.7.3 *Complexity* — Should weight, cost, and complexity be required in the equipment, these items of impact, where possible, shall be in the ground or terminal facility equipment. This requirement does not preclude a greater degree of self-sufficiency in aircraft systems where significant off-line operational usage is planned.

3.7.7.4 *Misalignment tolerances* — The transfer system at the threshold shall be conceived and designed to be generously tolerant in the amount of ULD misalignment acceptable.

3.7.7.5 *Control across threshold* — Lateral and longitudinal guidance devices shall be of a configuration to assure directional control of ULD loads during 'teetering' or 'bridging' conditions (*see* **3.3.1.4**).

3.7.7.6 *Drive force continuity* — Power drive force and control shall be continuous across the threshold area including the duration of 'teetering' or 'bridging' conditions (*see* **3.3.1.4**).

3.7.7.7 *Inadvertent cargo movement* — Safety devices shall be incorporated to preclude inadvertent movement of ULDs out of an open door when positioned within the system. Safety devices shall be incorporated to preclude inadvertent movement of ULDs into the aircraft.

3.7.8 *Ancillary cabin equipment* — The following cabin equipment installation shall be provided to facilitate the use of the cargo system during either loading/unloading or flight operations, as applicable.

3.7.8.1 *Interior lighting* — The minimum interior lighting provided shall be in accordance with that established by state and federal industrial regulatory agencies. These light values however, shall not be less than 54 1x at floor or walkway levels, and 108 1x in the area of primary cargo restraints requiring visual inspection and/or mechanical operation during loading/unloading.

3.7.8.2 *Threshold floor lighting* — The minimum threshold floor lighting shall be in accordance with that established by state of federal regulatory agencies. However, these light levels shall not be less than 108 1x at the ground equipment interface level.

3.7.8.3 *Intercom and public address system* — Intercom shall be provided between the flight deck and the cargo loading areas with provision to connect to the loading equipment/facility. The public address system shall be audible over and above the surrounding airport ramp ambient noise levels. The public address system shall also be audible over the aircraft interior noise of air conditioning and freight movement.

3.7.8.4 *Electrical power outlets* — Electrical power outlets of 400 Hz, 3-phase with a minimum rating of 1·3 kVA shall be located approximately every 5 m in the cargo compartment. This power shall be accessible to each stick of cargo and shall be available both on the ground and during flight.

3.7.8.5 *Walkways and anti-skid* — Where walkways are required for inspection, operation or maintenance of cargo equipment, access to the compartment shall be a minimum of 200 mm in width at the foot path and 380 mm clear shoulder at 1·5 m above the foot path floor. It shall be surfaced with an anti-skid material.

3.7.8.6 *Smoke detector/fire protection* — The smoke detector/fire protection provisions shall be in accordance with the appropriate airworthiness regulatory body.

3.7.8.7 *Placards* — Appropriate placards (stencils, decals, etc) shall be displaced in the cargo compartment to cover such items as fuselage stations, loading zones, emergency exits and instructions, equipment identification and operations, stowage provisions, capacities, limitations, restrictions, and warning.

3.7.8.8 *Cabin liners* — Suitable scuff damage resistant liners material shall be installed on the side walls of the cargo compartment to protect the airframe structure and to visibly show any damage which would require inspection.

3.7.8.9 *Drainage* — A drainage system shall be installed in the cargo compartment to remove water and other fluids which may blow in through open doors or be carried in or leak from ULDs or other cargo. No static pockets, pools or wells of fluids shall be allowed to accumulate. The system shall provide for the controlled removal of fluids in a manner to prevent conditions which may result in a manner to prevent conditions which may result in malfunction/non-operation of equipment or in corrosion of either equipment or structure.

3.8 *Materials, Parts and Processes* — Materials selected shall be of corrosion-resistant composition or protected by plating or other surface treatment.

3.8.1 *Dissimilar metals* — Unless protected against electrolytic corrosion, dissimilar metals shall not be used in intimate contact with each other.

3.8.2 *Fungus* — Materials and parts shall be non-nutrients for fungus or shall be treated prior to use. Materials shall be either naturally not water absorbant or shall be treated to be non-absorbant.

3.8.3 *Lubrication* — Wherever practical, mechanical parts shall be designed to operate without the use of grease or oil.

3.8.4 *Standard parts* — Standard, proven, and economical parts shall be used to the maximum extent consistent with reliability and performance.

3.8.5 *Flame resistance* — All materials and finishes shall meet the fire resistance requirements of the appropriate airworthiness regulatory body.

3.9 *Human Factors* — Sizing, forces to actuate, access to, and similar man-machine relationships of the operator to mechanical controls, and including electrical and hydraulic controls where applicable, shall reflect good human factors engineering practice.

3.10 *Interchangeability* — All like assemblies and replaceable parts shall be designed and manufactured to permit substitution without physical change to any part of the equipment.

3.11 *Workmanship* — All details of workmanship shall be of the highest grade consistent with the intent of this Indian Standard. There shall be no cracks, dents, scratches, burrs, sharp edges, foreign matter, or any other evidence of poor workmanship that will render the system unsuitable for the intended purpose.

4. Quality Assurance

4.0 In addition to the standard quality assurance and inspection procedures accorded to various components, assemblies, and installation during the manufacturing process, the following minimum qualification checks and/or tests shall be performed to verify that the requirements specified in **3** have been satisfied.

4.1 *Inspection* — The following minimun requirements of **3** shall be verified by inspection.

a) Foolproofing (**3.7.1.6**),
b) Exposed edges (**3.7.2.5**), and
c) Workmanship (**3.11**).

4.2 *Analysis* — The following minimum requirements of **3** shall be verified by review of analytical data:

a) Loads (**3.3.3.1**),
b) Deflections (**3.3.3.2**),
c) Restraint (**3.3.3.3**),
d) Crash conditions (**3.3.4**),
e) Uncertified ULDs (**3.7.4.7**)
f) Structural considerations (**3.7.6**),
g) Containment (**3.7.6.7**), and
h) Electrical power outlet (**3.7.8.4**).

4.3 *Demonstrations* — The following minimum requirements of **3** shall be verified by demonstrations:

a) Load access/inspection/verification (**3.2.9**),
b) Load/unload cycles (**3.3.1.1**),
c) Barriers (**3.3.4.1**),
d) Cargo monitoring (**3.6.2**),
e) ULD separation (**3.7.2.3**),
f) Guidance (**3.7.3**),
g) Rail location (**3.7.3.1**),
h) Restraint (**3.7.4**),
j) Longitudinal freedom (**3.7.4.1**),
k) Manloading (**3.7.4.3**),
m) Performance (**3.7.4.4**),
n) Positive indication (**3.7.4.5**),
p) Override (**3.7.5.2**),

q) Control (**3.7.5.5**),
r) Inadvertent cargo movement (**3.7.7.7**),
s) Intercom and public address (**3.7.8.3**),
t) Walkways (**3.7.8.5**),
u) Placards (**3.7.8.7**), and
v) Interchangeability (**3.10**).

4.4 *Tests* — There are two general categories of testing, namely, qualification testing and structural testing. The qualification tests generally cover environmental criteria but may be expanded to additionally cover endurance aspects of a life cycle nature. The structural tests are static in nature and applied static loads shall take into account the combined static and dynamic (where applicable) loads anticipated in service unless such dynamic loads are of a nature to make the combination thereof impractical. The following minimum requirements for conveyance, guidance, restraint, power, structural, optical (where selected), and ancillary systems, components, assemblies and installations of **3** shall be verified by formal tests:

a) Force (**3.3.1.3**),
b Load system alignments (**3.3.1.4**),
c) Environment (mechanical/electrical equipment only) (**3.7.1.2**)
d) Impact loads (**3.7.1.3**),
e) Power equipment (**3.7.5**),
f) Control (**3.7.5.1**),
g) Normal capability (**3.7.6.4**),
h) Special capability (**3.7.6.5**),
j) Interior lighting (**3.7.8.1**),
k) Threshold floor lighting (**3.7.8.2**),
m) Smoke detector/fire protection (**3.7.8.6**), and
n) Flame resistance (**3.8.5**).

EXPLANATORY NOTE

The dedicated aircraft addressed herein is to be an uncompromised all-freighter aircraft developed primarily for use in the civil transport industry.

The requirements of this standard are applicable but not limited to air-borne equipment which is subject to the directives of the appropriate air-worthiness regulatory body and which is designed to accommodate unitized cargo in the form of intermodal containers and other compatible unitized load devices. Intermodability in the context of this standard encompasses the air-road-rail-sea modes, and considers uncertified as well as certified Unit Load Devices (ULDs). This standard covers the fundamental prerequisites for the aircraft cargo compartment and the onboard cargo handling and restraining system. The cargo system and compartment considers primarily 2 440 mm wide, multiple bottom configuration ULDs. The cargo system and compartment should handle outsize cargo. The cargo system, compartment, and the cargo-related aircraft physical features should be sufficiently defined to establish specifications for ground interface mobile and/or fixed loading equipment and facilities with a goal of standardization thereof.

This standard is intended to assist air carriers in standardizing to the degree necessary to ensure the smooth flow of cargo between ground and aircraft and between various aircraft in the future. It is not intended to inhibit the development of new systems but rather to establish a solid interface for the introduction of such system.

In order to achieve international co-ordination on the subject, this standard is based on ISO 6833-1983 'Air cargo — Minimum requirements for future wide-body aircraft cargo systems and compartments (intermodal)', issued by the International Organization for Standardization (ISO).

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